

Mepsy

Methodology & Assumptions

This document describes the methodology and underlying assumptions for Mepsy: The Appliance & Equipment Climate Impact Calculator.

ABOUT MEPSY

Mepsy is an online tool to model the impacts of energy and carbon reduction policies for appliances and equipment. Mepsy's dynamic, user-friendly interface is designed to help policymakers, analysts, funders and other stakeholders identify and prioritize global and national efficiency policy opportunities and project the impacts of different policy options. The tool is free to use, and the underlying product data is updated regularly from multiple data sources.

The Mepsy model is based on a bottom-up stock accounting method that accumulates unit sales and retirements to estimate the number of appliances in use in each country (the stock), and multiplies it by the average unit energy consumption (UEC) under different policy scenarios to derive the national final energy consumption. The UEC reflects the efficiency and usage of products and can be adjusted by the user to reflect the impact of efficiency standards. The national energy consumption is finally multiplied by country-specific factors reflecting the transmission and distribution losses of the electric grid, the heat rate (efficiency of fossil fuel power plants), and grid emission factor (the CO₂ intensity of the electricity generation mix) to determine CO₂ emissions and primary energy consumption. The model is pre-loaded with data that allows the user to run analyses for 162 countries.

METHODOLOGY

The calculation methodology has been used by CLASP and other organizations for decades to evaluate the potential impact of appliance and equipment energy efficiency policies around the world. Unique among efficiency policy tools, Mepsy is free to use and is regularly updated with the latest research on product shipments and efficiency. Wherever possible, the calculator references precise stock, sales, and energy performance data from recent CLASP in-country market studies, or country-level estimates from reputable market research firms. Where country-level data for a particular product are not available, calculations are based on estimates from regional or global averages, accounting for differences in country population, economics, or climate as relevant to a particular appliance. Future and past shipments are extrapolated based on recent trends.

MODEL DATA AND ASSUMPTIONS

Below are general model data sources and assumptions for the following technologies: air conditioning, space heating, refrigerator-freezers, ceiling fans and portable fans, air conditioning, electric motors, televisions, and lighting products. Additional product data for refrigerated display cases, distribution transformers, and residential hot water heaters will be integrated in 2022. A more detailed report can be found [here](#).



GENERAL

- **Transmission & distribution losses:** US Energy Information Administration (EIA), “International”, [Data for Electricity Consumption and Distribution losses](#), 2018 data or earlier.
- **Heat rate:** Various sources including ADB, World Efficiency Council, GE, Lazard, BP, World Bank, and EIA, 2010-2019.
- **Grid emission factor:** International Financial Institutions Technical Working Group (IFI TWG) “[Harmonized Grid Emission Factor Data](#)”, 2019.



SPACE HEATING

- **Representative unit:** technology-dependent capacity from Pezzutto et Al. (2019). [Assessment of the space heating and domestic hot water market in Europe—Open data and results](#). *Energies*, 12(9), 1760: air-source heat pump (ASHP): 5.37 kW, ground-source heat pump (GSHP): 12.14 kW, boiler/furnace: 25.5 kW, electric resistance (ER): 9.76 kW, except for the following countries: USA, Canada ASHP: 10 kW; USA, Canada GSHP: 15 kW, USA condensing and non-condensing boiler/furnace (CB & NCB) 30 kW; USA ER: 10 kW; Russia ER: 5 kW; India ER: 5 kW; India CB & NCB: 15 kW; China ER: 6.5 kW.
- **Shipments:** Stocks obtained directly from national sources for each technology: Pezzutto in the EU; Hu et Al. (2017) and National Bureau of Statistics of China; US Energy Information Administration; Bhat & Rubab (2008) and Sivasakthivel et Al. (2012) in India; Natural Resources Canada); Pezzutto extrapolated to other countries based on heating degree days.
- **Efficiency:** BAU coefficients of performance (COPs) from Pezzutto: ASHP: 3.65, GSHP: 4.58, CB: 0.92; NCB 0.82; ER 0.99; MEPS based on CB replacing NCB and 50% of ASHP with 15% higher efficiency; BAT based on ASHP replacing 25% of ER and 40% of boilers; and 50% of ASHP with 15% higher efficiency.
- **Usage:** technology-dependent equivalent full-load hours from Pezzutto (2019), extrapolated to other countries based on population-weighted HDD ([KAPSARC Global Degree Days Database](#))
- **Average Lifetime:** 25.4 years based on US data for gas boilers in Franco et Al., “[Estimating Residential Appliance Lifetime for Energy Efficiency Policy Analysis](#)” 2018.



AIR CONDITIONING

- **Representative unit:** Residential air conditioner. Size varies by country depending on ratio of 3.5 kW and 7 kW systems, from United for Efficiency (U4E). “[Country Savings Assessments](#)”, September 2019.
- **Shipments:** Euromonitor, 2020.
- **Efficiency:** Varies by country depending on ratio of fixed- and variable-speed systems across the 3.5 kW and 7 kW systems, from United for Efficiency (U4E). “[Country Savings Assessments](#)”, September 2019. UEC in OECD countries based on regression of cooling degree days.
- **Usage:** Depends on climate zone of most populous city in each country, per U4E, “[Model Regulation Guidelines: Energy-efficient and Climate-friendly Air Conditioners](#)”, September 2019, p. 20.
- **Average Lifetime:** Varies by country depending on ratio of 3.5 kW and 7 kW systems. 8.4 years for 3.5 kW and 18.0 years for 7 kW systems based on US data for room and central AC in Lutz et Al., “[Using National Survey Data to Estimate Lifetimes of Residential Appliances](#)”, 2011.



REFRIGERATOR-FREEZER

- **Representative unit:** Residential refrigerator-freezer, with volume that varies by region, as estimated in U4E, “[U4E Country Savings Assessments: Methodology and Assumptions](#)”, 2019, p. 3.
- **Shipments:** Euromonitor, 2020 for all-refrigerators and refrigerator-freezers
- **Efficiency:** BAU, MEPS, and BAT UECs vary by region, as estimated in U4E, “[U4E Country Savings Assessments: Methodology and Assumptions](#)”, 2019, p. 3.
- **Usage:** continuous
- **Average Lifetime:** 17.7 years worldwide, based on US data in Lutz et Al., “[Using National Survey Data to Estimate Lifetimes of Residential Appliances](#)”, 2011.



ELECTRIC MOTORS

- **Representative unit:** 11.4 kW avg. 8-pole motor for centrifugal pumps and compressors based on stock-weighted worldwide average of medium (0.75-375 kW) and large (>375 kW) motors from Waide & Bruner, "[Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems](#)"; IEA Energy Papers, No. 2011/07; 7.1 kW avg. 8-pole motor for industrial fans based on Omdia shipments data, 2020.
- **Shipments:** Omdia shipments for centrifugal pumps, compressors, and industrial fans, 2020; data for 2018–2023.
- **Efficiency:** Meeting the MEPS requirements as indicated in U4E, "[Accelerating the Global Adoption of Energy-Efficient Electric Motors and Motor Systems](#)"; September 2014, p. 34; in countries with no standards, 1 percentage point below IE1. MEPS at IE3 (for countries already meeting IE3, MEPS is half-way between IE3 and IE4); BAT at IE4.
- **Usage:** Running at 62% average capacity for 3280 hours annually, based on Waide & Bruner, "[Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems](#)"; IEA Energy Papers, No. 2011/07;
- **Average Lifetime:** 7.7 years



CEILING AND PORTABLE FANS

- **Representative unit:** Portable fan: 16 in/400 mm; Ceiling fan: 48 or 52 in/1200 or 1300 mm
- **Shipments:** Euromonitor, 2020; data for 2005-2024
- **Efficiency:** BAU based on avg. service value in country or, if not available, latest MEPS level (e.g., 3.1 m³/min/W for ceiling fans in India; 2 m³/min/W for ceiling fans in USA); MEPS: 4 m³/min/W for ceiling, 1.08 m³/min/W for portable (for countries where BAU is higher than 4 m³/min/W for ceiling and 1.08 m³/min/W for portable, MEPS is half-way between BAU and BAT); BAT: 6 m³/min/W for ceiling, 1.7 m³/min/W for portable.
- **Usage:** National studies in US, EU, China, Brazil, India, and Indonesia extrapolated to other countries in region based on cooling degree days.
- **Average Lifetime:** 11 years for ceiling and 10 years for portable for most countries, with some differences in South Asia, Southeast Asia, and North America based on studies in India, Indonesia, and United States.



TELEVISION

- **Representative unit:** Region-average size and ratio of high definition (HD) versus ultra high definition (UHD), from Omdia 2020, data for 2020
- **Shipments:** Omdia 2020, data for 2010–2024
- **Efficiency:** BAU: average performance of models in country databases, weighted by distribution of shipments at that screen size in the region and country studies; MEPS: forthcoming EU MEPS levels, applied to region-average size and HD/UHD ratio (for countries where BAU is higher than forthcoming EU MEPS levels, MEPS is half-way between BAU and BAT); BAT: EU Tier 3 levels for consideration in 2025.
- **Usage:** Regional test procedures and studies, but typically 4-5 hours in on mode, except for Australia where the test method assumes 10 (Energy Ratings Australia, "[Televisions – AS/NZS 62087.2.2 Table Columns](#)", accessed from "[Product: Televisions](#)" on February 2, 2021).
- **Average Lifetime:** 7–14 years based on national studies in the US, India, South Africa and the EU (Urban et Al., p. 46: 2017 stock estimate divided by shipments from Omdia above; "Kiran et Al., "[A multivariate discrete grey model for estimating the waste from Mobile Phones, Televisions, and Personal Computers in India](#)"; Journal of Cleaner Production, forthcoming; Stats SA, "General Household Survey, 2019", p. 177 for TV penetration, divided by past shipments to estimate lifetime; European Commission, "[Commission Staff Working Document Impact Assessment for Electronic Displays](#)", January 10, 2019, p. 20.)



LIGHTING

- **Representative unit:** Seven lighting technologies to cover the full range – incandescent / halogen, compact fluorescent lamps (CFL), linear fluorescent lamps (LFL), high intensity discharge (HID) lamps, and three light emitting diode (LED) retrofits for these conventional sources: general service LED lamps, tubular LED lamps and outdoor LED lamps. Efficacy, wattage and lifetime values are defined for each technology.
- **Shipments:** Guidehouse. [Market Data: Energy Efficient Lighting for Commercial Markets](#), published 1Q 2019, [Market Data: Industrial and High Bay Lighting](#), published 4Q 2019, [Market Data: Outdoor Lighting Systems](#), published 3Q 2020, [Market Data: Residential Energy Efficiency Lighting and Lighting Controls](#), published 1Q 2021. Intra-sectoral shipment apportionment made based on UNEP U4E global market analysis.
- **Efficiency scenarios:** (1) MEPS levels to phase-out conventional lighting technologies (i.e., non-LED); (2) BAT levels to evaluate high energy savings scenario with high-efficacy LED lamps (all conventional lighting technologies phased-out); (3) [the African Lighting Amendment](#) to the Minamata Convention on Mercury to phase-out CFL and LFL only.
- **Efficiency, wattage, sectoral operating hours, and lamp lifetime:**

TECHNOLOGY	EFFICACY	WATTAGE	OPERATING HOURS		LIFETIME	
			DOMESTIC	PROFESSIONAL	DOMESTIC	PROFESSIONAL
	LUMENS/ WATT	WATTS	HOURS	HOURS	YEARS	YEARS
Incandescent/Halogen	12	70	1.5	10	2.2	0.3
Compact Fluorescent	55	15	3	10	6.4	1.9
LED General Service	<i>varies</i>	<i>varies</i>	3	10	13.7	4.1
Linear Fluorescent	60	40	8	10	6.2	4.9
LED Tubular	<i>varies</i>	<i>varies</i>	8	10	13.7	11.0
High Intensity Discharge	90	135	11	11	5.0	5.0
LED Outdoor	<i>varies</i>	<i>varies</i>	11	11	12.5	12.5



COMPLIANCE

- **Compliance feature:** The compliance feature in the Mepsy provides a more accurate picture on energy and CO2 reduction predictions, by incorporating estimated compliance rate with policy.
- **Compliance rate:** Varies between Excellent (95%) and Low (50%), and initially pre-set at Average (75%). The lowest range of 50% compliance rate was estimated to account that some of the products on the market are compliant with proposed policies even in cases when no compliance processes nor policy enforcement are in place.
- **Compliance rate change:** The tool is pre-set with the same compliance rate for the policy analysis period - between Policy Effective Year and Analysis End Year - under assumption that estimated compliance rate in the market will not change. However, the user can choose different estimated compliance rate for the Analysis End Year as compared to Policy Effective Year if they anticipate improvements or changes in policy enforcement. The rate of change in the compliance rate is assumed incremental between the two years.
- **Impacts:** The same compliance adjustment is incorporated in BAT and Efficiency Policy scenarios for CO₂ and energy reduction estimates.

COMING SOON

- Refrigerated display cases, residential hot water heaters, and distribution transformers